Nanocomposite Films with Embedded Metal Nanoparticles Near the Percolation Threshold - Physico-Chemical Properties and Applications

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The present talk reviews properties of nanocomposite films (NF) with high volume fractions (close to the percolation threshold) of metal nanoparticles embedded in polymer or ceramic matrix. In this regime, physical properties like the d.c. electrical conductivity and the permittivity are extremely sensitive on the nanoparticle concentration and separation. The morphology of the nanocomposites (particle size and distribution) which were prepared by PVD methods, depend on the host and metal properties as well as on the preparation parameters like deposition rate and substrate temperature. As a consequence, a percolation threshold in the conductivity was observed at different critical concentrations of nanoparticles ranging from 15 to 40 vol. %. It is shown also that optical, magnetic and chemical properties may be varied strongly close to percolation. Thus the index of refraction can be tuned over a wide range, and surface plasmons, occurring for noble metals in the visible range, can be shifted to the infrared regions. As potential applications of the NF near the percolation threshold electromagnetic, optical, chemical, and biosensoric devices are considered. Properties of the metal-ceramic NF will be discussed taking into account their application as electromagnetic sensors. Polymer-metal NF chemical sensors operate on the principle of swelling of the polymers in the presence of organic vapors and take advantage of the strong dependence of physical properties of the composite near the percolation threshold due to changes in the cluster separation upon swelling. Moreover, a novel approach, based on photochromic polymer–metal composites is discussed.

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